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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/500,654	07/02/2004	Michel Puech	Q82315	2879

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EXAMINER
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DAHIMENE, MAHMOUD

ART UNIT	PAPER NUMBER
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1765

SHORTENED STATUTORY PERIOD OF RESPONSE	MAIL DATE	DELIVERY MODE
3 MONTHS	02/05/2007	PAPER

**Please find below and/or attached an Office communication concerning this application or proceeding.**

If NO period for reply is specified above, the maximum statutory period will apply and will expire 6 MONTHS from the mailing date of this communication.

## Office Action Summary

Application No.

10/500,654

Applicant(s)

PUECH ET AL.

Examiner

Mahmoud Dahimene

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --  
**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 12 December 2006.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1-16 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-16 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some \* c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
  - ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO/SB/08)  
Paper No(s)/Mail Date \_\_\_\_\_
- 4) ☐ Interview Summary (PTO-413)  
Paper No(s)/Mail Date. \_\_\_\_\_
- 5) ☐ Notice of Informal Patent Application
- 6) ☐ Other: \_\_\_\_\_

### ***Withdrawal of Finality***

Applicant's request for reconsideration of the finality of the rejection of the last Office action is persuasive in view of the fact that the reference of Rattner filing date of May 1, 2002 is after the filing date of FR 02/00032 January 3, 2002, and, therefore, the finality of that action is withdrawn.

### **DETAILED ACTION**

#### ***Claim Rejections - 35 USC § 103***

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

2. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

3. Claims 1-9, 11-15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Laermer et al. (US 5,501,893) (Laermer (1)), in view of Laermer et al. (US 2002/0144974) (Laermer (2)) and Cho (US 2002/0134749).

Regarding claims 1, 2, 6, 7, 15, Laermer (1) discloses a method of etching silicon anisotropically, comprising:

Etching a silicon substrate protected in part by a mask using a plasma of etching gas to make cavities in zones of the substrate that are not protected by the mask, and depositing a protective polymer on the walls of the cavities using a plasma of passivation gas (abstract),

It is noted that Laermer (1) is silent about a plasma of cleaning gas that removes the protective polymer, Laermer (1) relies on ion bombardment from the first step to remove the polymer.

Laermer (2) discloses a similar process wherein a polymerization step is used (using gases like CHF<sub>3</sub>, C<sub>3</sub>F<sub>6</sub> or C<sub>4</sub>F<sub>8</sub>, page 2, paragraph 0024), and wherein the etching step includes an etching gas such as SF<sub>6</sub> combined with a polymer removing gas such as oxygen (page 2, paragraph 0018).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to expect the second step of Laermer (2) to remove the polymer from the bottom zones of the etched features since Laermer discloses "A method of anisotropic etching of silicon with structures, preferably defined with an etching mask, by using a plasma, with a polymer being applied during a polymerization step to the lateral border of the structures defined by the etching mask, then being partially

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removed again during the following etching step and being redeposited in deeper side walls of the structure newly formed due to the etching reaction, and the etching is performed with an etching gas containing 3 to 40 vol % oxygen" (abstract) in addition to the fact that anisotropic etching is obtained, which suggest the polymer from the bottom zones of the etched features is removed otherwise no further etching can be performed.

Cho discloses a silicon etch process citing "The polymer material acts as a passivation layer as it is not readily etched by the SF<sub>6</sub>-derived etchant. An oxygen (O<sub>2</sub>) plasma removes the polymer passivation layer 24 from the bottom of the etched portion of the substrate so that further etching leaves sidewall passivation layers 26 on the already etched portion of the trench. A further etching cycle etches deeper into the substrate producing the intermediate structure illustrated in FIG. 9(d). The steps illustrated in FIGS. 9(b)-9(d) are repeated to perform further etching cycles" (page 2, paragraph 0013).

Therefor, It would also have been obvious to one of ordinary skill in the art at the time the invention was made to modify the method of Laermer (1), willing to accept a longer duration etching process, to further improve the etching process by performing 3 steps comprising an etching step, a polymerizing step, and a cleaning step, wherein the plasma of cleaning gas is more effective than the etching gas at removal of the protective polymer, because the combined references of Laermer suggest the three features of etching/polymerizing/de-polymerizing are conventionally used for silicon etching. One of ordinary skill in the art would have been motivated to separate the three steps in order to independently control each of the etching/polymerizing/de-

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polymerizing steps individually which is desirable in order to control the profile smoothness and sidewall slopes of the etched features (as well as the photoresist selectivity as suggested by Laermer (1)) by de-coupling the polymer removal step from the etching step.

As to claim 3, neither references cited suggest that the application of the plasma of cleaning gas overlaps the preceding or following steps.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the plasma cleaning step without overlap with the preceding or following steps.

As to claims 4, 5, Laermer discloses sulfur hexafluoride as the etching gas (column 4, line 1) and  $\text{CHF}_3$  for the polymerization step (column 4, line 26).

As to claim 8, 9, It is noted that Laermer is silent about a bias potential (prestress) for the cleaning step. However, Laermer discloses "a substrate prestress for ion acceleration is applied to the substrate electrode" (column 4, line 7) the substrate bias is preferably between 5 and 30 Volts (column 4, line 9).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Laermer by applying a similar low ion acceleration potential during the cleaning step in order to attract the ions of the cleaning plasma as well during cleaning. One of ordinary skill in the art would have been motivated to apply a low bias (between 5 and 30 V) in order to remove the polymer without subjecting the substrate to unnecessary higher ion energies. It is noted

that Laermer's suggested bias range overlaps the applicants range. Overlapping ranges are held obvious.

As to claim 11, it is noted that Laermer is silent about the plasma cleaning pressure in a range of 0.5 Pa to 10 Pa, and preferably in the range 2 Pa to 5 Pa (or 4-75 mT and 15-37 mT respectively).

Laermer teaches 10-100  $\mu$ bar (7.5-75 mT) for the polymer removal/etch step. Overlapping ranges are held obvious.

As to claim 12, 13, 14, it is noted that Laermer is silent about the duration of the cleaning step. However, cleaning time appears to be related to the degree of removal. As a result, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to select any cleaning duration that would effectively remove the desired level of polymer including the specific duration claimed by applicants, because cleaning time is proportional to the degree of removal. Applicants have not shown anything unexpected with respect to the specifically claimed cleaning duration.

### ***Claim Rejections - 35 USC § 103***

4. Claim 10 is rejected under 35 U.S.C. 103(a) as being unpatentable over Laermer et al. (US 5,501,893) (Laermer (1)), Laermer et al. (US 2002/0144974) (Laermer (2)) and Cho (US 2002/0134749) as applied to claims 1-9 above, and further in view of S. Wolf and R.N. Ttauber (Silicon Processing for the VLSI Era, Volume 1-Process Technology, Lattice Press, 1986, pages 544-545)

As to claim 10, it is noted that Laermer is silent about increasing progressively the bias potential from one cleaning step to another.

Wolf teaches the bias potential accelerates ions toward the wafer surface (pages 544-545).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the process of Laermer by applying a similar low ion acceleration potential during the cleaning steps and progressively increasing the bias potential as the etched recess (cavity) becomes deeper because Wolf teaches ion acceleration toward the wafer is a function of the bias. One of ordinary skill in the art would have been motivated to progressively increase the bias voltage on the substrate in order for the accelerated cleaning ions to reach the bottom of the cavity as deeper recesses require higher ion energies.

### ***Claim Rejections - 35 USC § 103***

5. Claim 16 is rejected under 35 U.S.C. 103(a) as being unpatentable over Laermer et al. (US 5,501,893) (Laermer (1)), Laermer et al. (US 2002/0144974) (Laermer (2)) and Cho (US 2002/0134749) as applied to claims 1-9 above, and further in view of Ohara et al. (US 6,277,756)

Regarding claim 16, Laermer teaches deep structures having vertical edges can be realized with very high etching rates in silicon substrates.

It is noted that Laermer is silent about a specific aspect ratio and micro-relief for the etched feature in silicon.



Ohara discloses a method for manufacturing a semiconductor device wherein a deep trench with an aspect ratio of 33.4 is etched in silicon (column 5, line 47). The method of Ohara involves repeated steps of etch and deposition.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the modified method of Laermer, discussed above, continuing the 3-step cycling until a trench having an aspect ratio greater than 30 is reached because the method of Laermer is specifically intended to etch deep features. One of ordinary skill in the art would have been motivated to etch a high aspect ratio trench with the modified method of Laermer because the method allows a good profile control.

### ***Response to Arguments***

6. Applicant's arguments, see pages 1-3, filed 12/12/2006, with respect to the rejection(s) of claim(s) 1-16 under 35 USC § 103 have been fully considered and are persuasive in view of the fact that the reference of Rattner filing date of May 1, 2002 is after the filing date of FR 02/00032 January 3, 2002. Therefore, the rejection has been withdrawn. However, upon further consideration, a new ground(s) of rejection is made in view of Laermer et al. (US 5,501,893) (Laermer (1)), Laermer et al. (US 2002/0144974) (Laermer (2)) and Cho (US 2002/0134749).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Mahmoud Dahimene whose telephone number is (571) 272-2410. The examiner can normally be reached on week days from 8:00 AM. to 5:00 PM..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on (571) 272-1465. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.



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